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Invited Review

The one-dimensional cutting stock problem with usable leftovers – A survey

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ABSTRACT

In this article, we review published studies that consider the solution of the one-dimensional cutting stock problem (1DCSP) with the possibility of using leftovers to meet future demands, if long enough. The one-dimensional cutting stock problem with usable leftovers (1DCSPUL) is a problem frequently encountered in practical settings but often, it is not dealt with in an explicit manner. For each work reviewed, we present the application, the mathematical model if one is proposed and comments on the computational results obtained. The approaches are organized into three classes: heuristics, item-oriented, or cutting pattern-oriented.

1. Introduction

The cutting stock problem consists of cutting a set of parts available in stock (called objects) to produce smaller pieces (called items) in specified quantities, optimizing an objective function. Examples of objective functions include minimizing the total waste, minimizing the cost of cutting the objects, minimizing the total number of objects cut, maximizing profit and minimizing production costs.

One solution to the cutting stock problem, often called the cutting plan, is provided by a set of cutting patterns and their corresponding frequencies, in other words, how many times each cutting pattern must be cut to produce the items. A cutting pattern defines a subset of items to be cut from an object. In the case where two or more dimensions of the items are relevant for the cutting problem, a cutting pattern also includes the layout of the items to be cut in the object.

The cutting stock problem arises in many industrial processes where objects can be steel bars, rolls of paper or aluminum, wood boards or metal sheets, printed circuit boards, glass or fiber glass sheets, leather pieces and others. In these industries, reducing production costs and/or improving efficiency are often associated with using appropriate cutting plans and/or cutting strategies.

The economic importance of such problems and the difficulties in solving them have motivated the operations research community to develop more efficient methods to solve them. Various articles about the cutting stock problem can be found in the literature, as can be seen in review articles and special editions: Hinxman (1980), Dyckhoff, Kruse, Abel, and Gal (1985), Dyckhoff (1990), Dyckhoff and Wäscher (1990), Dyckhoff and Finke (1992), Dowsland and Dowsland (1992), Sweeney and Parternoster (1992), Martello (1994a, 1994b), Bischoff and Wäscher (1995), Dyckhoff, Scheithauer, and Terno (1997), Arenales, Morabito, and Yanasse (1999), Wang and Wäscher (2002), Hifi (2002), Oliveira and Wäscher (2007), Wäscher, Haußner, and Schumann (2007) and Morabito, Arenales, and Yanasse (2009). Additional references may be found in ESICUP (2013).

Each practical situation where cutting stock problems arise has its specific features, constraints and objectives, which often prevents the application of existing models and algorithms in a straightforward manner.

One problem often encountered is the use of leftovers of cutting patterns. This problem has been addressed directly in the literature only recently, although it was cited in the early 1970s by Brown (1971). The cutting stock problem with usable leftovers was studied by Arbibi, Marinelli, Rossi, and Di Iorio (2002) in an automobile industry. In this industry, the items cut were used to produce belts with a fixed width and different lengths. Retails (i.e., the usable leftovers) remaining during the cutting process could be stitched and used to manufacture other different goods. According to the authors, with the possibility of using leftovers, a considerable

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